Instrumentation

General Information

The (Mission name) payload system will draw heavily upon 5 previous small satellite missions developed by the same NASA/ARC team that will develop (Mission name). These missions, with numerous similar subsystems and features, are described in *Appendix 9, Heritage*: GeneBox (launch/nominal operation from July 2006); GeneSat-1 (launch/nominal operation from December 2006); PreSat (launch, spacecraft failed to reach orbit, August 2008); PharmaSat (scheduled launch, January 2009 aboard a Minotaur I, full flight qualification complete); O/OREOS (scheduled launch: December 2009 aboard a Minotaur IV).

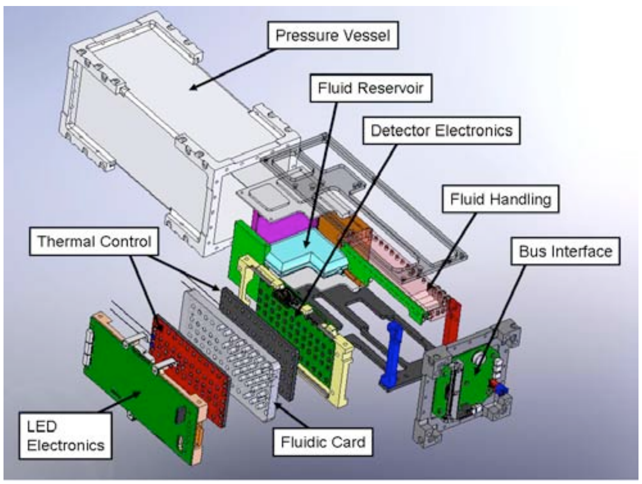

Figure F-1. *Exploded view of (Mission name) payload with major subsystems identified.*

The (Mission name) payload system, Figure F-1, will integrate support of microorganism growth, optical measurement of organism viability and growth, thermal control, passive control of relative humidity and pressure, active fluid management, and multiple sensors for temperature, pressure, and relative humidity. These and other (Mission name) subsystems will leverage the high-heritage subsystems and overall architecture of the NASA/ARC-developed family of nanosatellites: GeneBox (launch/nominal operation from July 2006); GeneSat (launch/nominal operation from December 2006); PreSat (launch, August 2008 aboard Falcon 1/Flight 3, which failed to reach orbit); PharmaSat (scheduled launch: January 2009 aboard a Minotaur I); O/OREOS (scheduled launch: December 2009 aboard a Minotaur IV). Like GeneSat-1, GeneBox, PreSat, and PharmaSat, the (Mission name) payload will occupy two of the 10-cm cubes of a three-cube nanosatellite, for an overall satellite size of 10 x 10 x 30 cm.

Utilizing the existing PharmaSat payload design to save significant cost and schedule, (Mission name) will accomplish three critical functions in a fully autonomous free-flyer platform: (1) provide environmental control and life support for growth of (organism) in 4 fully independent sets of 12 fluidic microwells, over a baseline mission time of XX months and an extended mission time of XX months; (2) monitor growth of (organism) cultures using 3-color absorbance measurements every XX hr in each microwell; (3) telemeter the resulting data to Earth along with periodic sensor readings of temperature, pressure, relative humidity, microgravity, and system status. (Mission name) implements

PI-guided science focused on key questions in fundamental space biology while remaining within a defined set of constraints on mass, budget, and schedule, necessitating a close working relationship between principal investigator, co-investigators, and technology development team. Flexibility of experimental design and hardware implementation, without compromise of scientific rigor, will be vital to mission success.

The (Mission name) mission will reach an orbit of (TBD km, TBD inclination). The microorganism will be (organism), and observation of the effects of microgravity is the science goal. Consequently, the (Mission name) payload subsystems will be identical to those of PharmaSat (including its substantial GeneSat/GeneBox heritage), with very few modifications:

The multiwell fluidics card will utilize 4.5 – 7 mm diameter wells, most likely the same 6.5 mm as GeneSat; the fluidic-well layout will be the same 48-well layout as used in PharmaSat as shown in Figure F-2. Additionally, A top/bottom filter and inlet/outlet strategy, identical to that developed for O/OREOS and presently undergoing initial prototype testing, makes a more compact footprint at each well, as there are no filters or channels beside the wells, may be considered; During Phase A, well volumes will be optimized between 75 and 250 μL/well by selection of fluidic card thickness and diameter according to card fabrication, and optical considerations, somewhere in the range defined by GeneSat (3.5 mm), PharmaSat (8 mm) and O/OREOS (12 mm); fluidic card materials will be selected according to biocompatibility results for the strain(s) of (organism) selected for flight.

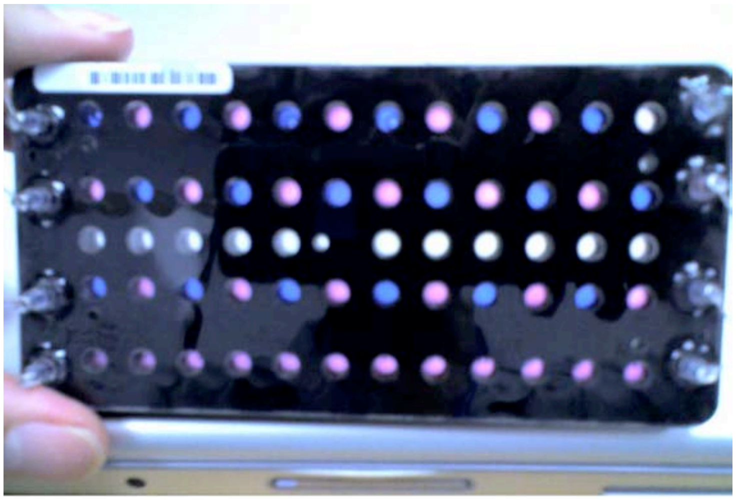

Figure F-2 *PharmaSat fluidic card which the (Mission name) card will closely resemble, with Alamar Blue in the fluidic wells; (organism) is present in those wells that have changed from blue to pink; blue wells are no-(organism) controls.*

The (Mission name) pressure vessel

The (Mission name) payload pressure vessel is identical to that used on the PharmaSat mission: a three piece aluminum structure illustrated below, Figure F-3. Each piece is gold plated to optimize thermal properties. The square cylindrical body is fitted with threaded inserts for connecting the two end covers, and has threaded inserts for connecting to the solar panels; thus the pressure vessel forms an integral part of the entire satellite structure. At the fasteners there are Ultem washers between the pressure vessel and the solar panels for thermal isolation. The two end cover pieces have grooves for o-rings to form a seal where they contact the cylindrical body. The front cover is fitted with a pass-through connector that is hermetically welded. On the outside of the front cover an electronics board is soldered to the connector and fastened to threaded inserts. There are also threaded inserts on the inside of the front cover to attach the payload module. A margin of space is provided around the cylindrical body where multi-layer insulation (MLI) is fitted. As with PharmaSat, the (Mission name) pressure vessel will be sealed at ambient (1 atmosphere) pressure.

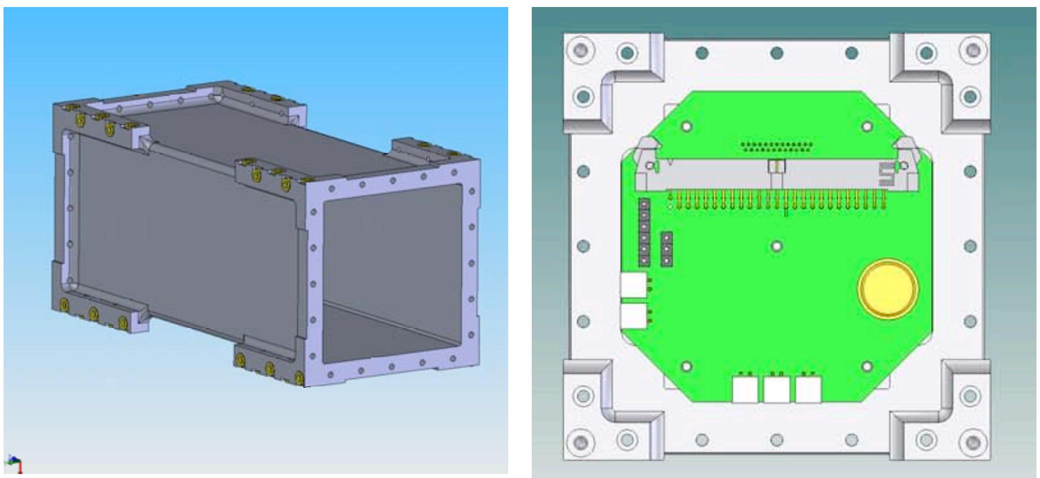

Figure F-3*: (Mission name) Pressure Vessel,*
identical to that used for PharmaSat.

(Mission name) Fluidic Approach

The (Mission name) fluidic system, Figure F-6 below, will be a simpler version of the configuration developed and tested to flight readiness for PharmaSat. The number of fluidic microwells is the same as PharmaSat's 48, providing statistically significant *n*'s. The wells will be fluidically addressed independently in 4 groups of 12 to provide component redundancy and to enable four different initiation times for the biology experiment: (1) at the start of the mission, shortly after orbital stabilization; (2) at t = XX weeks; (3) at t = XX weeks; (4) at t = XX weeks. Membrane filters at the entrance and exit of each well keep the (organism) from flowing out of the wells during growth medium exchange. The fluidics card will be comprised of 4 physically separate independent 12-well "strips" to enable effective thermal isolation of each set of 12 from the others. A dozen additional wells will be provided for solid-state optical control/calibration samples as in PharmaSat.

Pumps and valves will be either 4 of GeneSat's passive spring-based pumps (one per bank of wells) or a single PharmaSat-flight-qualified miniature diaphragm pump (KNF NF 5S, 32 grams; 0.8 W @ 6V) miniature metering pump (Lee Co. LPVX0502600BC; positive-displacement, stepper-driven piston; 160 grams; 1.5 W when operating; 500 0.1 μL piston steps provide 50 μL per piston stroke in < 1 sec); a trade study comparing for the redundancy of the 4 spring-based pumps relative to the controlled-volume dispense capability of the powered pump will be made in Phase A/B. Valves will be flight-qualified "inert" solenoid valves (Lee Co. LHDA0531315HA; 850 mW when actuated—during medium introduction and periodically (daily) activated for a few sec in conjunction with the valve for a given bank of wells to maintain full fluid volume only).

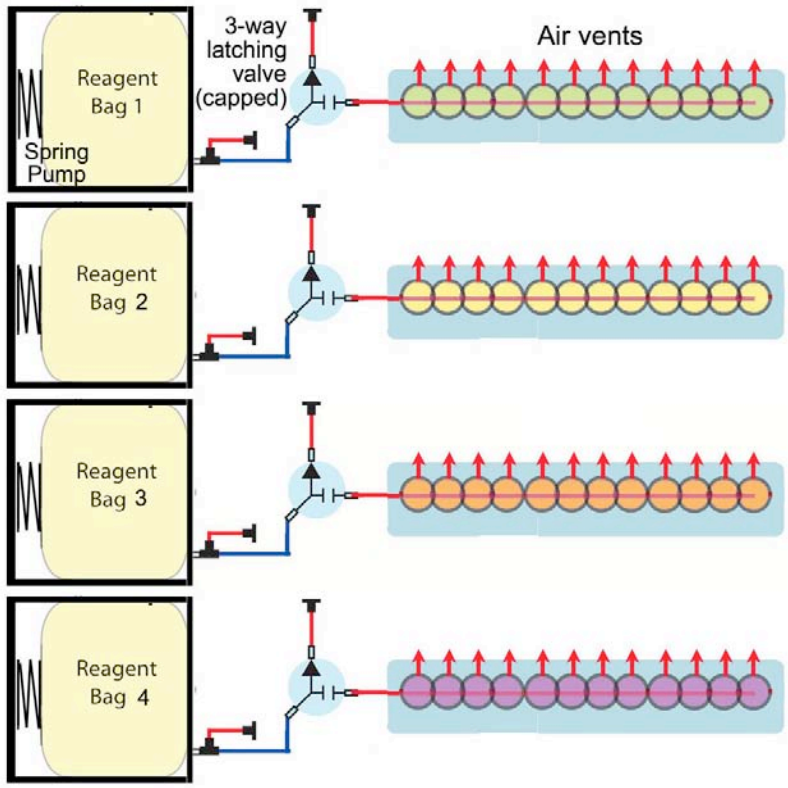

Figure F-6. *(Mission name) fluidic system configuration, drawing upon PharmaSat, O/OREOS, and GeneSat components and approach. The 4 strings of wells are separately addressed; nutrient is provided to a set of 12 wells on software command to start (organism) growth at t = 0, XX weeks, XX weeks, and XX weeks. Spring pressure on the waste bag serves to replace any evaporative fluid loss from the wells.*

(Mission name) Optical Subsystem

The PharmaSat optical system, now fully tested, integrated, and flight qualified (and launched without attaining orbit on PreSat), provides 3-color LED illumination and TAOS intensity-to-frequency sensors at each of the 60 well locations of the PharmaSat fluidics card (see photo in Figure F-7). The (Mission name) optical subsystem will be essentially identical to that of PharmaSat: 3-color LEDs (Lite-On; 470nm (26nm half-width), 525nm (35nm half-width) and 615nm (18nm half-width)) are located at the "top" of each well, providing measurements of optical density as well as two additional wavelength-band absorbance measurements for determining viability of sample organisms.

(Mission name) Thermal Control Subsystem

The thermal control system will be very similar to that of PharmaSat, using Kapton-and-patterned-nichrome heaters with feedback control via multiple temperature sensors (Analog Devices AD590). To reduce power consumption, the fluidic card will be physically divided into 4 separate 12-well "strips", each of which will have a separate heater and Al thermal spreaders. A temperature of XX° +/- 1.5° C will be maintained for the duration of active measurement of each strip of 12 wells.

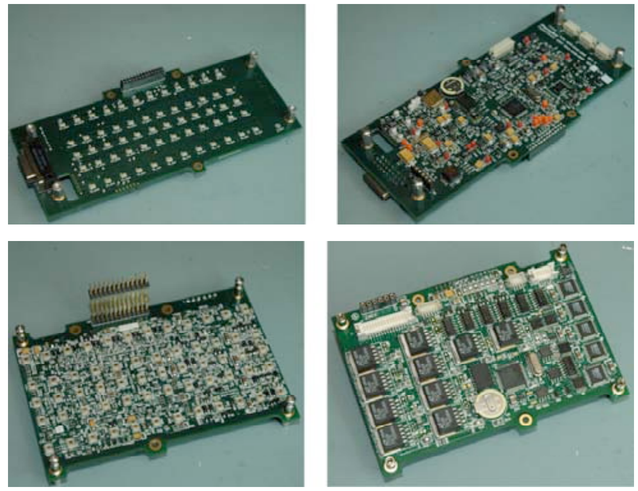

Figure F-7. *Photographs of PharmaSat optical subsystem showing both sides of LED driver board (top) and both sides of detector board (bottom), each with 60-well capability (48 fluidic and 12 reference wells). The (Mission name) optical system will be identical.*

(Mission name) Sensor Subsystems

Sensors for temperature (measured in 3 locations on each of the 4 fluidics card "strips" and 2 additional locations within the payload pressure vessel), pressure, and relative humidity will be the same as GeneSat and PharmaSat. Measurements of microgravity will be derived from the currents from the solar panels on the 4 long-axis faces of the satellite during the ~ 2/3 of each 90-min orbit that the satellite is illuminated by the sun.